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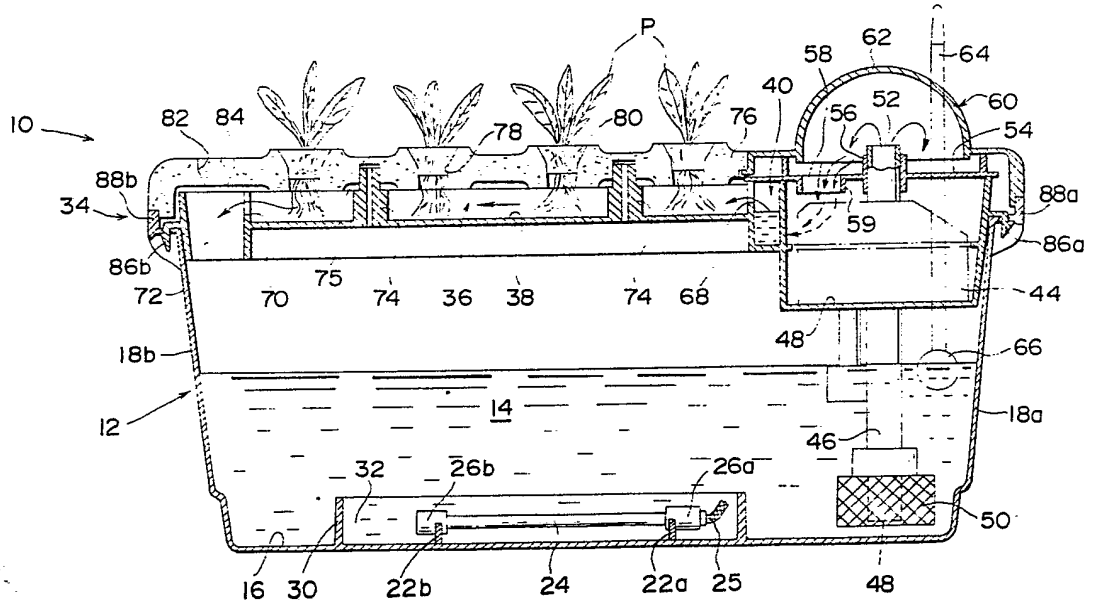
(54) Hydroponic apparatus

(57) A hydroponic plant growing apparatus includes an arrangement for promoting the entrapment of air into a nutrient solution being circulated by a suction pump 44 through a nutrient supply tray 34. A baffle plate 54 in combination with a hood member 60 receives the pump output flow and redirects it to an intermediate nutrient supply section 40 in the tray. An upstream weir 68 is provided between the intermediate nutrient supply section 40 and a hydroponic section 36 wherein the roots of plants are immersed in the nutrient solution. A downstream weir 70 is provided between the hydroponic section and a drainage opening 72 to return the solution to a container. An electric heater element 24 is also provided on the bottom floor of the container which includes a circumferential wall 30 defining an open-top chamber to accommodate the heater in the event of an accidental loss of the solution from the container.

F I G. 1



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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FIG. 1

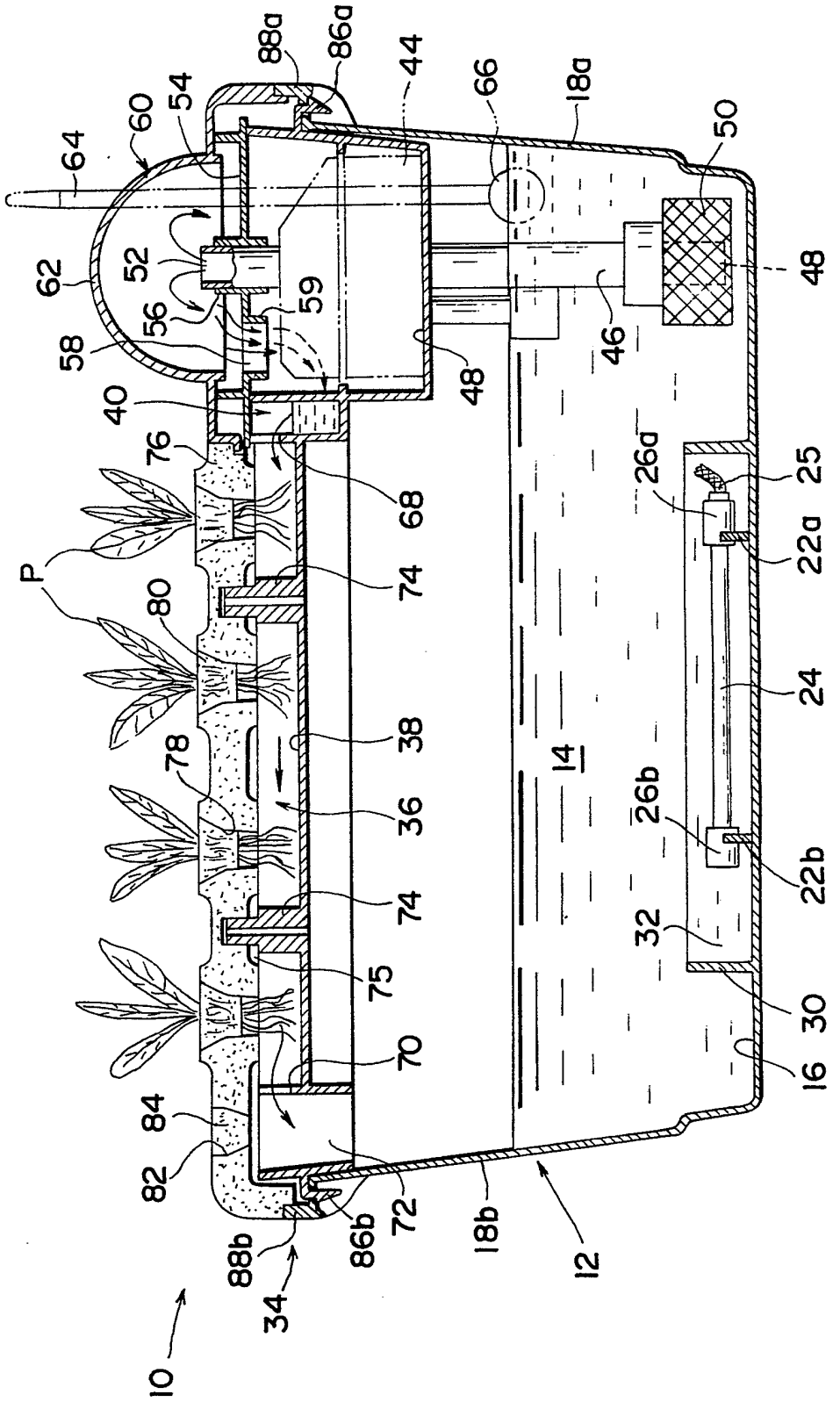

FIG. 2

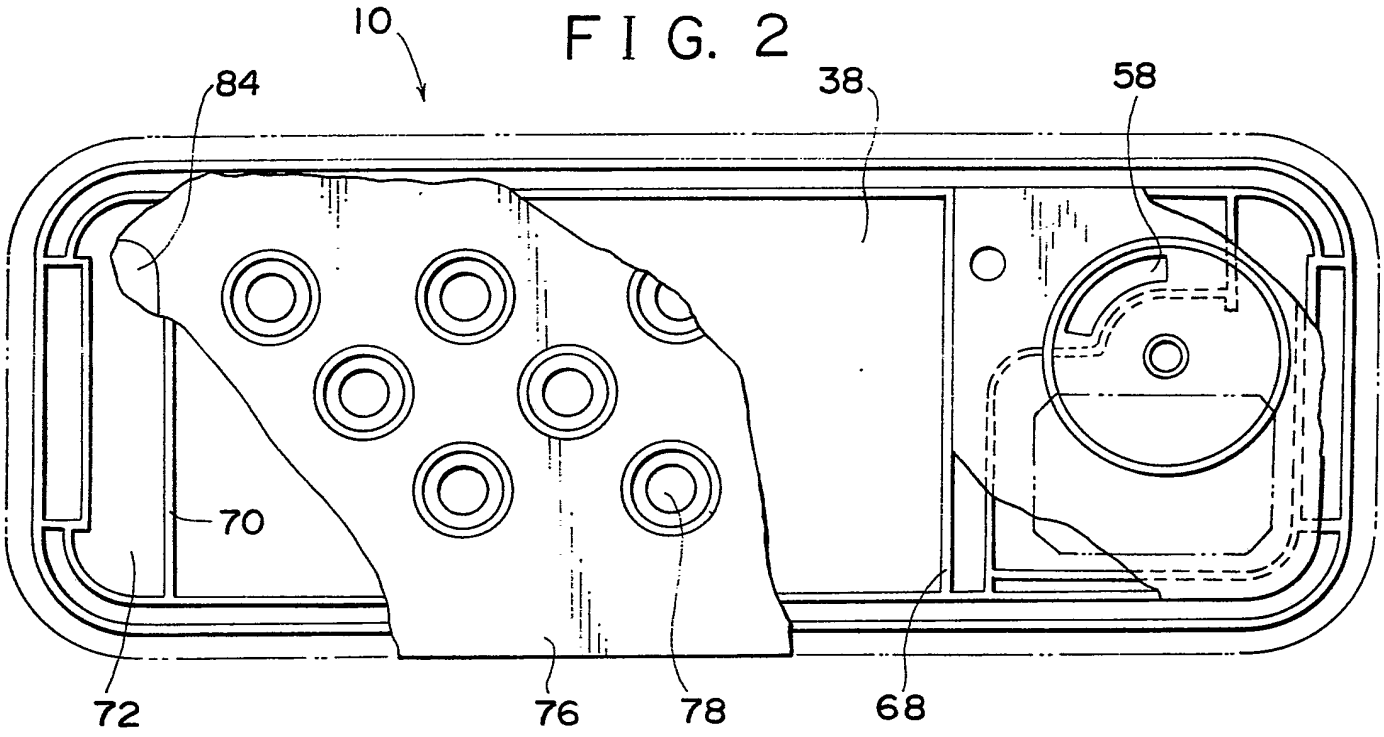

FIG. 3

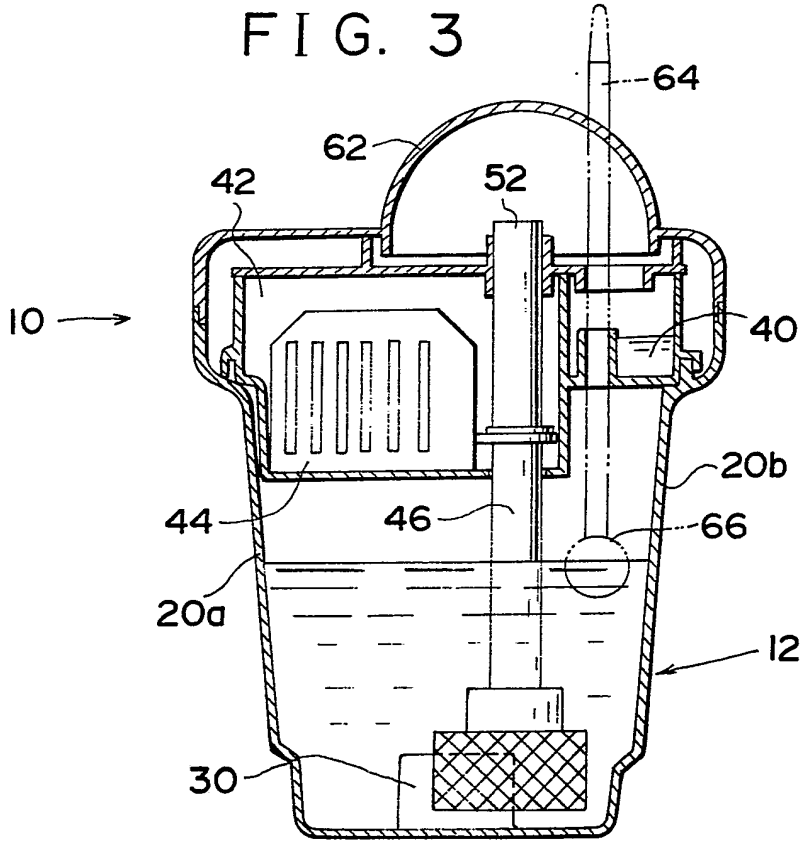

FIG. 4

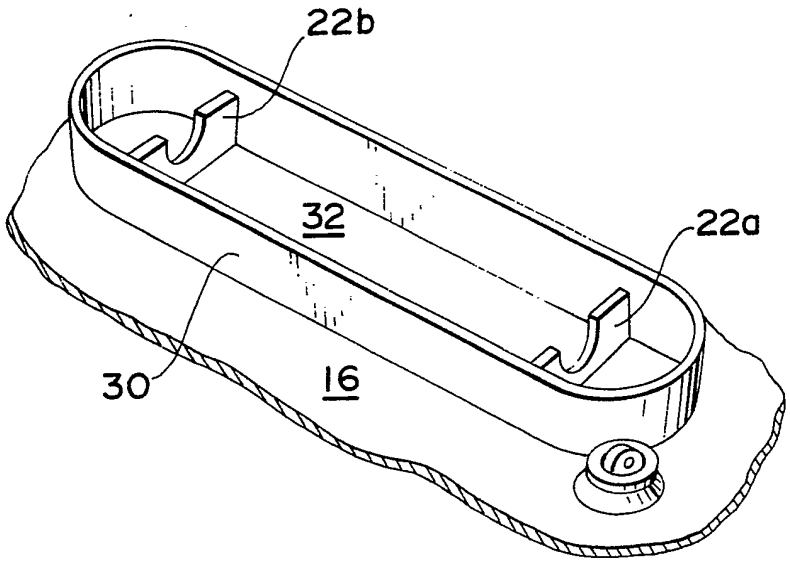

FIG. 5

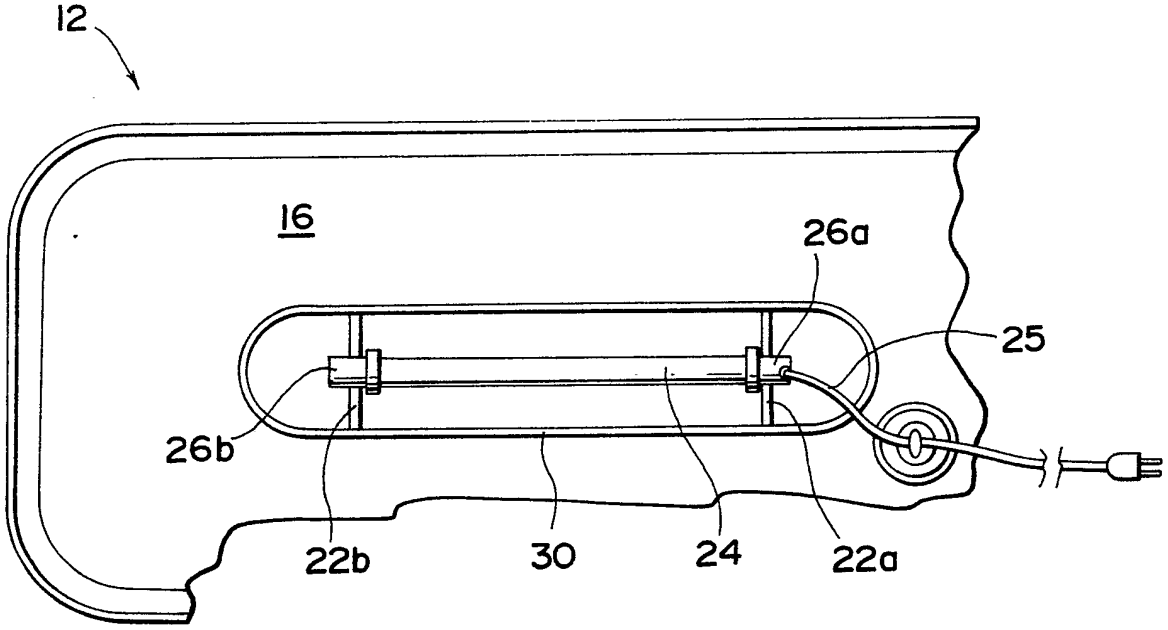

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FIG. 6

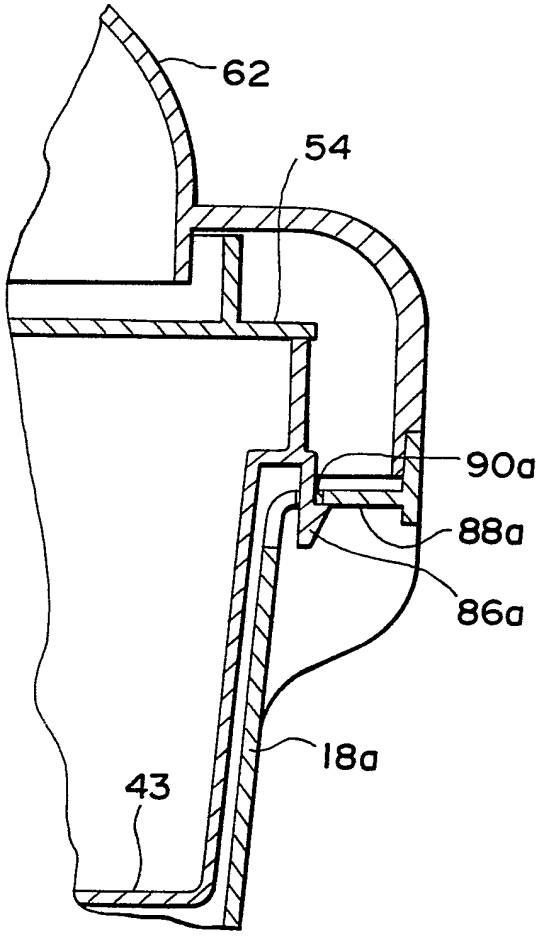

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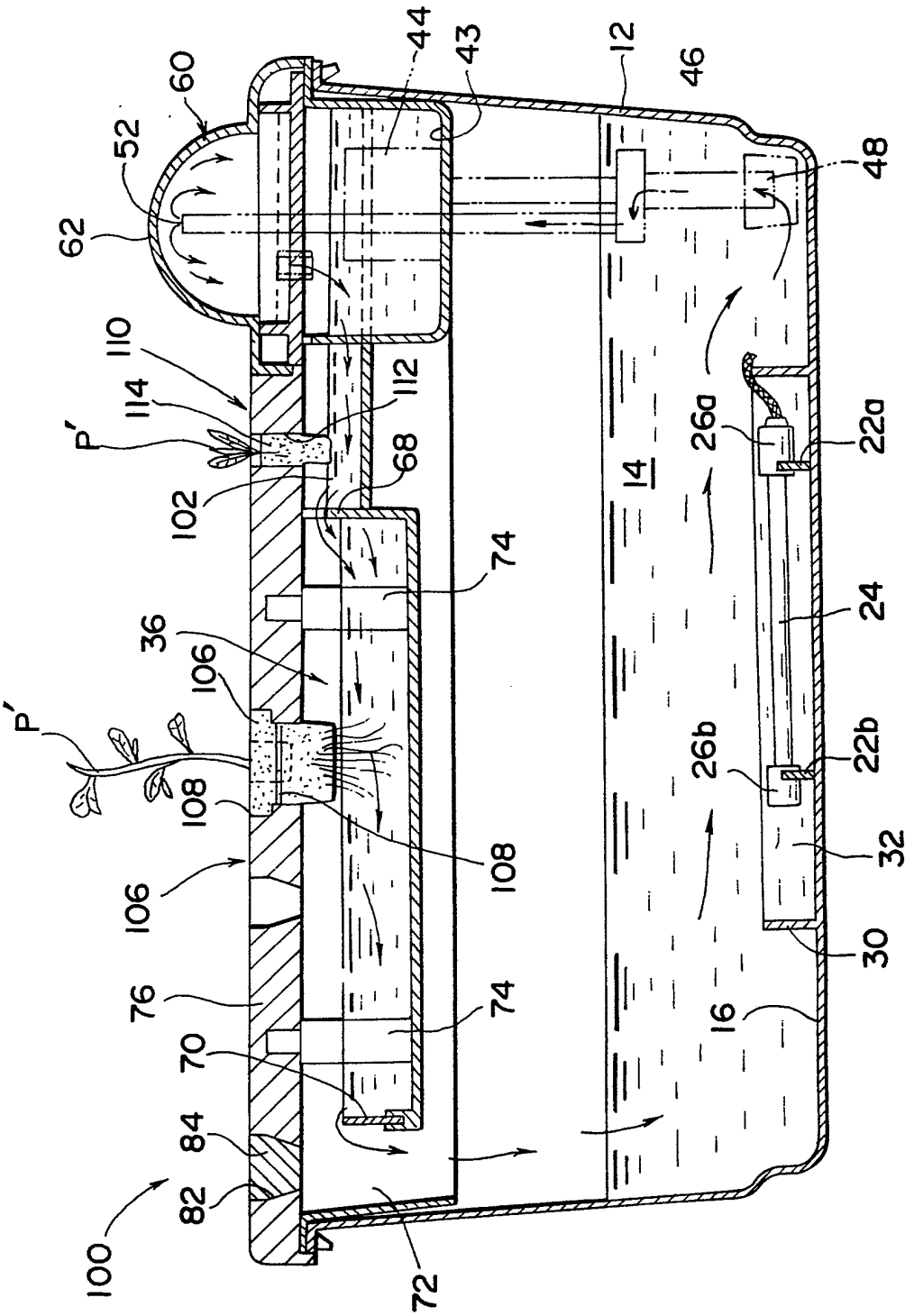
FIG. 7



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HYDROPONIC PLANT GROWING APPARATUS

The present invention relates generally to an improved hydroponic plant growing apparatus and, more particularly, to such an apparatus for home use wherein a suction pump is employed to provide a circulated flow of nutrient solution for growing vegetables, exotic flowering plants or the like.

As is well known, a compact hydroponic apparatus for home use typically comprises a rectangular open-top container for holding a nutrient solution, a nutrient supply tray removably mounted on top of the container, a suction pump for circulating the nutrient solution in the container to the supply tray, a plant support panel fixedly mounted on the supply tray and having a plurality of openings for receiving plants with their roots immersed in the pumped nutrient solution in the tray.

In such a conventional hydroponic apparatus, the pumped solution is delivered directly to the roots of the plants in the supply tray; hence, the solution tends to be insufficiently aerated before reaching the plant roots. Furthermore, when the nutrient solution is at a relatively low level, replenishing the container with nutrients sometimes results in undissolved nutrient granules being pumped to the supply tray where they might lodge near the plant roots. When this occurs, localized fertilizer burning of the roots and consequent damage to the plant would occur.

The hydroponic apparatus of this type also employs a heater element normally disposed on the container bottom surface. The heater element is energized to heat the nutrient solution during the winter months. Should an accidental loss of the solution occur due, for example, to a container failure, the heater element may surface above the level of the solution and become overheated thereby causing serious damage to the heater per se and other components of the apparatus.

An object of the present invention is to provide an improved hydroponic apparatus and, according to the present invention, there is provided a hydroponic apparatus comprising: a container for holding a nutrient solution; a nutrient supply tray assembly removably mounted on top of the container and including a first section for holding a limited amount of the nutrient solution, a second section disposed next to the first section and a drainage opening formed in the tray assembly adjacent the second section; pumping means for circulating the nutrient solution in the container to the first section; a plant support panel fixedly mounted to the tray assembly above the second section and having a plurality of openings for receiving plants therein with their roots immersed in the nutrient solution in the second section; first weir means provided between the first section and the second section; and second weir means provided between the second section and the drainage opening, whereby the pumped nutrient solution in the first section overflows the first weir means into the second section and then overflows the second weir means into the drainage opening to return into the container while entrapping air into the nutrient solution during overflowing to thereby rejuvenate the nutrient solution.

According to another aspect of the invention, there is provided a hydroponic apparatus comprising: a container for holding a nutrient solution; a nutrient supply tray assembly removably mounted on top of the container and including a first section for holding a limited amount of the nutrient solution, a second section disposed on one side of the first section, a third section disposed on the other side of the first section and a drainage opening formed in the tray assembly adjacent the second section; pumping means provided in the third section for circulating the nutrient solution in the container to the first section; baffle means provided in the third section to redirect the flow of the nutrient solution from the suction pipe to the first section in a manner that

promotes the entrapment of air into the nutrient solution; a plant support panel fixedly mounted to the tray assembly above the second section and having a plurality of openings for receiving plants therein with their roots immersed in the nutrient solution in the second section; first weir means provided between the first section and the second section; and second weir means provided between the second section and the drainage opening, whereby the pumped nutrient solution in the first section overflows the first weir means into the second section and then overflows the second weir means into the drainage opening to return into the container while entrapping air into the nutrient solution during overflowing.

According to yet another aspect of the invention, there is provided a hydroponic apparatus comprising: a container for holding a nutrient solution; a nutrient supply tray assembly removably mounted on top of the container and including a first section for holding a limited amount of the nutrient solution, a second section disposed next to the first section and a drainage opening formed in the tray assembly adjacent the second section; pumping means for circulating the nutrient solution in the container to the first section; a plant support panel fixedly mounted to the tray assembly above the second section and having a plurality of openings for receiving plants therein with their roots immersed in the nutrient solution in the second section; first weir means provided between the first section and the second section; second weir means provided between the second section and the drainage opening, whereby the pumped nutrient solution in the first section overflows the first weir means into the second section and then overflows the second weir means into the drainage opening to return into the container while entrapping air into the nutrient solution during overflowing; heater means provided on the bottom floor of the container; and circumferential wall means provided on the container bottom floor and defining an open-top chamber for accommodating the heater means therein, the height of

the circumferential wall means being greater than that of the heater means, whereby the heater means is always kept immersed in the nutrient solution within the open-top chamber in the event of an accidental loss of the nutrient solution from the container.

The invention will be better understood from the following detailed description of preferred embodiments of the invention, when taken in conjunction with the accompanying drawings, in which:

Figure 1 is a front elevation, in section, of a hydroponic plant growing apparatus in accordance with the present invention.

Figure 2 is a partially cutaway plan view of the hydroponic plant growing apparatus of Figure 1.

Figure 3 is a side elevation, in section, of the hydroponic plant growing apparatus of Figure 1.

Figure 4 is a perspective view of a circumferential wall provided on the bottom floor of a container to accomodate an electric heater element therein;

Figure 5 is a plan view of the electric heater element positioned on the bottom floor of the container shown in Figure 1.

Figure 6 is an enlarged fragmentary sectional view showing the manner in which a nutrient supply tray assembly is removably mounted on top of the container shown in Figure 1.

Figure 7 is a front elevation, in section, of a second embodiment of the invention, showing an additional hydroponic area formed as part of an intermediate nutrient supply section to grow seeds therein.

Referring now to the drawings and in particular to Figures 1 to 3, there is shown an improved hydroponic apparatus 10 adapted especially for home use and constructed in accordance with the teachings of the present invention. Numeral 12 indicates a generally rectangular container made of a synthetic resin material for holding a nutrient solution 14. The container 12 includes a bottom floor 16, spaced end walls 18a and 18b and spaced side

walls 20a and 20b extending therebetween. The bottom floor 16 has a pair of spaced ribs 22a and 22b thereon which extend in parallel to each other to support an electric heater element 24 above the bottom surface of the container 12. Each rib 22a, 22b has a semi-circular notch for receiving a respective end of the electric heater element 24, as best seen in Figure 4. A cylindrical sheath 26a, 26b made, for example, of rubber is sealingly provided on each end of the electric heater element 24, as shown in Figure 5. An electric cord 25 having a water-proof sheath extends from one end of the electric heater element 24 for connection to an exterior control unit (not shown). The control unit is operable to maintain the nutrient solution at a temperature suitable for growth of plants and especially for preventing freezing of the solution when the hydroponic apparatus is used outdoors in winter.

As best seen in Figures 4 and 5, a circumferential wall 30 in the form of a low, generally elliptic, open-top cylinder is provided on the bottom floor 16 of the container 12 and surrounds the electric heater element 24.. The wall 30 and ribs 22a and 22b may be formed integrally on the container bottom floor 16. The circumferential wall 30, together with the container bottom floor 16, defines an open-top chamber 32 for holding the nutrient solution. It is important that the circumferential wall 30 have a vertical height slightly greater than that of the horizontally disposed electric heater element 24 to thereby ensure that the heater element 24 be always maintained in an immersed condition even in the event of an accidental loss of the solution due, for example, to a container failure or breakage. It should be understood that the present invention is not limited to the particular configuration of the circumferential wall 30 as illustrated and any other forms of the wall can be employed so long as they serve to keep the heating element immersed at all times.

A nutrient supply tray assembly, generally indicated at 34, is removably mounted on the container 12

at its top. The tray assembly 34 essentially consists of a hydroponic section 36 having a substantially flat bottom surface 38, an intermediate nutrient supply section 40 disposed in juxtaposition with the hydroponic section 36 and a pump housing section 42.

The bottom surface 38 of the hydroponic section 36 may have a longitudinally sloping contour being inclined slightly from the right to left as viewed in Figure 1. The intermediate nutrient supply section 40 has a common end wall 68 to the hydroponic section 36, which extends transversely to the container in a straight manner, and the opposite end wall having a curved configuration as indicated by the dotted lines in Figure 2. The intermediate nutrient supply section 40 has a bottom surface which is disposed slightly below the bottom surface 38 of the hydroponic section 36, as best seen in Figure 1. The pump housing section 42 is formed complementary to the intermediate nutrient supply section 40 and has a bottom surface 43 which is disposed further below that of the intermediate nutrient supply section but above the highest level of the nutrient solution, as seen in Figures 1 and 3. A suction pump 44 is fixedly supported on the bottom floor 48 of the pump housing section 42 for pumping the nutrient solution from the container 12 into the intermedate nutrient supply section 40. A suction pipe or conduit 46 extends downwardly from the suction pump 44 through an opening in the bottom floor 43. The suction pump 44 has an inlet 48 which is positioned slightly above the container bottom surface 16. It is preferable to have the suction inlet 48 substantially equal to, or more preferably, lower than, the top of the circumferential wall 30, in order to avoid the solution becoming stagnated near the bottom of the container 12. The suction inlet 48 of the pipe 46 may preferably be enclosed by a screen 50 of fine mesh size to prevent undissolved nutrient granules or foreign materials possibly present in the nutrient solution from passing into the hydroponic section 36.

Solution flow baffle means in the form of

a horizontally disposed plate 54 is provided over the suction pump 44 in such a manner as to cover the intermediate nutrient supply section 40 and the pump housing section 42. The baffle plate 54 has a circular opening surrounded by an integral sleeve 56 for sealingly receiving the upper portion of the suction pipe 46. The baffle plate 54 also has a circumferential wall defining a chamber on the plate, which chamber is adapted to receive the pump output flow from the top outlet of the suction pipe 46. An arcuate outlet 58 is formed in the plate 54 for allowing the nutrient solution to flow into the intermediate nutrient supply section 40. The baffle plate 54 may have a downwardly extending, integrally formed skirt 59 surrounding the arcuate outlet 58. As seen in Figure 2, the artuate outlet 58 is positioned above a portion of the intermediate nutrient supply section 40 so that the pumped nutrient solution may not flow into the pump compartment.

A hood or cover member 60 is provided above the pump compartment and cooperates with the circumferential wall of the baffle plate 54 to contain the nutrient solution within the chamber defined thereby. The hood 60 includes a dome-like closure portion 62 which is advantageously centered with the suction pipe top outlet 52. The height of the suction pipe top outlet 52 is selected such that the nutrient solution leaving the outlet may impinge against the interior surface of the dome 62 and then flow down along the dome's rounded interior surface in all directions. In this manner, the hood 60 serves not only to avoid undesirable infiltration of dust, insects or the like into the nutrient solution but also to prevent the nutrient solution from splashing to the outside. It should be noted that the aforesaid arrangement acts to promote the aeration of the nutrient solution and thus rejuvenate it. The entrapped air will also act to prevent the decomposition of the nutrients in the solution which can adversely affect the growth of the plants. The level of the nutrient solution in the container 12 may be visually and continuously checked by using a conventional level guage 64

which extends through the closure dome 62, the flow baffle plate 54 and the pump compartment floor 48. The level gauge 64 has a bulb float 66 mounted at its lower end.

With continued reference to Figure 1, a weir 68 is provided in the end wall dividing the intermediate nutrient supply section 40 and the hydroponic section 36. Another weir 70 is formed in the opposite end wall of the hydroponic section 36 to the intermediate nutrient supply section 40. Both weirs 68 and 70 may extend over the entire length of the end walls. It is preferable that the upsteram weir 68 may have a uniform vertical height substantially greater than that of the downstream weir 70. A drainage opening 72 is formed in the tray assembly 34 near the downstream weir 70 to allow the nutrient solution overflowing the downstream weir 70 to be discharged into the container 12. With this arrangement, the nutrient solution collected in the intermediate nutrient supply section 40 can flow over the upstream weir 68 into the hydroponic section 36 uniformly along the transverse length of the upstream weir 68 in a manner similar to the downstream weir 70. This will also act to promote the aeration of the nutrient solution thus rejuvenating it.

The hydroponic section 36 has several locating and supporting posts 74 provided on the bottom floor 38 in a suitably spaced relationship to each other. A plant support panel 76 is fixedly supported by the tray assembly above the hydroponic section 36 by inserting the locating posts 74 into corresponding recesses 75 in the interior surface of the panel. The plant support panel 76 also has a number of generally frusto-conical openings 78 formed therein. Inserted into each opening 78 is a plant P with the upper portion of the root being enveloped or wrapped by an inert support 80 made of urethane or the like, the roots of each plant being substantially immersed in the flowing nutrient solution. Further, the plant support panel 76 is provided at its one end with a frusto-conical replenishing port 82 which is normally plugged at

84, as shown in Figure 1. Such a port 82 is preferably positioned directly above the drainage opening 72 in the tray assembly 34 at a point sufficiently remote from the suction pipe inlet 48 for the reason that will become apparent hereinafter.

As best seen in Figure 6, the tray assembly 34 has several pairs of depending resilient hook members 86a, 86b at the opposite ends thereof while the container 12 is provided at the top ends thereof with flanges 88a and 88b, respectively. The flanges 88a and 88b have openings 90a and 90b for interlockingly receiving the hook members 86a and 86b of the tray assembly 34, respectively, in a snap-fitting fashion. This arrangement is well known in the art and does not form part of the present invention; thus, no further description thereof may be needed.

In operation, a plurality of plants P to be grown using the present invention are prepared by attaching the inert supports 80 to the upper portions of the plant roots in a manner that surrounds them. The plants thus prepared are manually inserted one by one into the associated openings 78 of the tray assembly's plant support panel 76 in such a manner that a substantial portion of each root extends into the nutrient solution in the hydroponic section 36. Prior to such insertion of plants, the nutrient solution 14 is introduced into the container 12 to a predetermined level.

The suction pump 44 is then energized to move the solution in the container 12 upwardly through the suction pipe 46. The solution spouting out of the suction pipe's top outlet 52 will impinge against the central portion of the dome's interior surface and then flow down the interior surface to the baffle plate 54. In this process, the surrounding air is entrapped into the nutrient solution resulting in an increase in the amount of oxygen dissolved in the solution thus rejuvenating the latter. The nutrient solution then flows toward the arcuate opening 58 and falls in streams therethrough into the intermediate

nutrient supply section 40 while again entrapping the surrounding air therein. When the solution in the intermediate nutrient supply section 40 has reached the same level as the upstream weir 68, overflows of the nutrient solution occur along the entire length of the upstream weir 68. In this process, further entrapment of the air in the nutrient solution occurs. It is to be noted that once such an overflow condition begins, it establishes a constant flow of the nutrient solution from the intermediate nutrient supply section 40 into the hydroponic section 36.

When the hydroponic area 36 becomes filled to a predetermined level defined by the height of the downstream weir 70, the solution begins to overflow the downstream weir 70 and flows through the drainage opening 72 into the container 12 while entrapping the air in this process also. It is to be understood that in such an overflow condition, the nutrient solution in the hydroponic section 36 remains at the predetermined level and is constantly replaced by a fresh solution containing a sufficient amount of dissolved oxygen.

The circulated and rejuvenated flow of the nutrient solution provided by the present invention creates an improved growing environment wherein an increased and uniform growth rate of plants is achieved without endangering the plants due to localized high concentrations of the nutrients.

When the level guage 64 indicates that the solution in the hydroponic section 36 has become significantly low, the user can remove the plug 84 to open the replenishing port 82 and add therethrough the required amounts of water and an aqueous nutrient solution in concentrated form. Since the replenishing port 82 is located considerably remote from the inlet 48 of the suction pipe 46, the concentrated aqueous nutrients will become dilluted through mixing with the water until they reach the suction inlet 48. This, coupled with the agitating action of the suction pump 44, will effectively

eliminate the possibility of undissolved plant nutrients being delivered directly to the roots of a plant causing localized fertilizer burning of the roots and consequent damage to the plant. Furthermore, with the provision of the circumferential wall 30 surrounding the heater element 24, it should be noted that it the event of a container failure and consequent extensive loss of the nutrient solution, there is no possibility that the heater element 24 becomes overheated causing severe damage to the container 12 and other components of the hydroponic apparatus.

Figure 7 shows a modified large hydroponic apparatus 100 which is adapted to grow specific kinds of plants including fruits and vegetables such as, for example, melons or tomatoes. This embodiment is essentially identical to that illustrated in Figures 1 to 6 except in the provision of an additional hydroponic area 102 which also serves as intermediate nutrient supply section. The additional hydroponic section 102 is advantagenously used to sprout seeds of such fruits or vegetables. To this end, a plant support panel 76 comprises a major portion 106 having a plurality of enlarged openings 108 and an extended portion 110 located above the additional hydroponic area 102. The extended portion 110 has a plurality of reduced diameter openings 112 into which small porous inert supports 114 of urethane material are snugly fitted with seeds therein. In order to supply the seeds with the nutrients through a capillary action, the bottom portion of each urethane support 114 should be immersed in the nutrient solution in the additional hydroponic section 102, whose level is defined by the upstream weir 68 to be higher than that of the solution in the hydroponic section 36.

When the seeds grow into seedlings as shown at P' in Figure 7, the small supports containing the seedlings are removed from the openings 112 for their repositioning and further growing. The small supports 114 thus removed are inserted into larger urethane supports 106 dimensioned to fit into the openings 108 of the major panel portion 106. In this case, it is preferable to retain each

small support 114 within the respective larger support 116 by using, for example, a rubber band 118 passing around the latter. Thereafter, the larger supports 116 are forcibly fitted into the larger diameter openings 112. As a result, the seedling will grow as shown at P" in Figure 7. Preferably, other unused openings 78 in the panel's major portion 106 are plugged for preventing dust from entering the interior of the apparatus. The operation of the second embodiment is essentially the same as that of the first embodiment except that it requires specific procedures mentioned above.

The foregoing description serves to illustrate the invention, the metes and bounds of the invention being defined by the appended claims.

WHAT WE CLAIM IS:

1. A hydroponic plant growing apparatus comprising: a container for holding a nutrient solution; a nutrient supply tray assembly removably mounted on top of the container and including a first section for holding a limited amount of the nutrient solution, a second section disposed next to the first section and a drainage opening formed in the tray assembly adjacent the second section; pumping means for circulating the nutrient solution in the container to the first section; a plant support panel fixedly mounted to the tray assembly above the second section and having a plurality of openings for receiving plants therein with their roots immersed in the nutrient solution in the second section; first weir means provided between the first section and the second section; and second weir means provided between the second section and the drainage opening, whereby the pumped nutrient solution in the first section overflows the first weir means into the second section and then overflows the second weir means into the drainage opening to return into the container while entrapping air into the nutrient solution during overflowing to thereby rejuvenate the nutrient solution.

2. A hydroponic plant growing apparatus as claimed in Claim 1, wherein the tray assembly includes a third section disposed next to the first section, the pumping means comprising a suction pump provided within the third section and a vertically disposed suction pipe through which the nutrient solution is supplied from the container to the first section, the suction pipe having a bottom inlet immersed in the nutrient solution in the container and a top outlet for allowing the solution to spout therefrom.

3. A hydroponic plant growing apparatus comprising: a container for holding a nutrient solution; a nutrient supply tray assembly removably mounted on top of the container and including a first section for holding a limited amount of the nutrient solution, a second section disposed on one side of the first section, a third section

disposed on the other side of the first section and a drainage opening formed in the tray assembly adjacent the second section; pumping means provided in the third section for circulating the nutrient solution in the container to the first section; baffle means provided in the third section to redirect the flow of the nutrient solution from the suction pipe to the first section in a manner that promotes the entrapment of air into the nutrient solution; a plant support panel fixedly mounted to the tray assembly above the second section and having a plurality of openings for receiving plants therein with their roots immersed in the nutrient solution in the second section; first weir means provided between the first section and the second section; and second weir means provided between the second section and the drainage opening, whereby the pumped nutrient solution in the first section overflows the first weir means into the second section and then overflows the second weir means into the drainage opening to return into the container while entrapping air into the nutrient solution during overflowing.

4. A hydroponic plant growing apparatus as claimed in Claim 3, wherein the baffle means comprises a horizontally disposed plate member having formed therein a first opening through which the suction pipe extends and a second opening in fluid communication with the first section; and a hood member provided over the third section to enclose it, whereby the pumped nutrient solution from the suction pipe impinges against the interior surface of the hood member, flows down onto the plate member and then flows through the second opening into the first section.

5. A hydroponic plant growing apparatus as claimed in Claim 1, 2, 3 or 4, wherein the plant support panel has a replenishing port positioned remote from the botttom inlet of the suction pipe and adapted for use in supplying additional nutrient solution to the container.

6. A hydroponic plant growing apparatus as claimed in Claim 5, wherein the replenishing port is positioned directly above the drainage opening in the tray

assembly.

7. A hydroponic plant growing apparatus as claimed in Claim 1, 2, 3, 4, 5 or 6, wherein the the plant support panel has an extended portion disposed over the first section and having a plurality of openings for receiving and sprouting seeds therein.

8. A hydroponic plant growing apparatus comprising: a container for holding a nutrient solution; a nutrient supply tray assembly removably mounted on top of the container and including a first section for holding a limited amount of the nutrient solution, a second section disposed next to the first section and a drainage opening formed in the tray assembly adjacent the second section; pumping means for circulating the nutrient solution in the container to the first section; a plant support panel fixedly mounted to the tray assembly above the second section and having a plurality of openings for receiving plants therein with their roots immersed in the nutrient solution in the second section; first weir means provided between the first section and the second section; second weir means provided between the second section and the drainage opening, whereby the pumped nutrient solution in the first section overflows the first weir means into the second section and then overflows the second weir means into the drainage opening to return into the container while entrapping air into the nutrient solution during overflowing; heater means provided on the bottom floor of the container; and circumferential wall means provided on the container bottom floor and defining an open-top chamber for accommodating the heater means therein, the height of the circumferential wall means being greater than that of the heater means, whereby the heater means is always kept immersed in the nutrient solution within the open-top chamber in the event of an accidental loss of the nutrient solution from the container.

9. A hydroponic plant growing apparatus as claimed in Claim 8, wherein the bottom inlet of the suction pipe is positioned at a level lower than the top of the

circmferential wall.

10. A hydroponic plant growing apparatus as claimed in Claim 8 or 9, wherein the heating means comprises an electric heater element.

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